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EVALUATION OF MIL-L-23699 LUBRICATING
OIL PERFORMANCE IN THE J79 ENGINE

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Trenton, New Jersey

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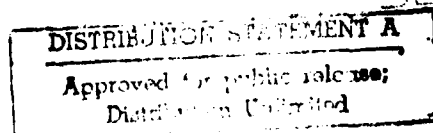
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13. ABSTRACT An evaluation was made of the service performance characteristics of MIL-L-23699B oils in the J79 engine. Operational experience and problems, lubricant condition, and the condition of lubricant wetted engine components at overhaul are discussed. Recommendations are made concerning the expected life of MIL-L-23699 oils in this engine.		

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INTRODUCTION.

1. By reference a, the Lubricants and Power Drive Systems Division of the Naval Air Propulsion Test Center (NAPTC) was assigned the responsibility of analyzing the service performance of lubricating oils. This assignment was established to assure maximum performance and cleanliness of lubricating oils in service. This goal is accomplished through chemical and physical testing of field samples, analysis of service problems when they arise, and the evaluation of deposition characteristics through inspection of service engine components.
2. Performance of MIL-L-23699 oils, in service, can vary from engine to engine. Deposition characteristics and useful oil life will usually vary with engine model. Therefore, the service performance of lubricating oils must be evaluated for each engine. This project, reference b, concerns such an evaluation of the J79 turbojet engine. This evaluation was separated into two distinct areas. The first area was concerned with uncovering lubricant system problems (real or potential) and determining deposition characteristics of MIL-L-23699 oils in the J79 engine. This work was performed by inspecting engines and discussing engine mechanical condition and performance at Naval Air Rework Facilities (NARF's), Intermediate Maintenance Activities (IMA's), and operating squadrons. The second area consisted of evaluating the chemical and physical changes in the lubricating oils during actual service use in the J79-GE-10 engine. This evaluation provides information relative to the useful life of the lubricant. A squadron oil sampling program was conducted for this purpose. It should be noted that the engines involved in these two areas were not the same specific engines.

CONCLUSIONS.

3. The performance of MIL-L-23699 oils with regard to the retention of original oil deposition, chemical and physical characteristics is excellent in the J79 engine for operating periods up to 300 hours.
4. The projected useful life of MIL-L-23699B oils in this engine, based on tests conducted on used engine oil samples, is 600 hours.

RECOMMENDATION.

5. Under normal J79 operating conditions, MIL-L-23699B oil should be changed after 600 hours of operation.

DISCUSSION.Performance - Engine Condition

6. The performance characteristics of MIL-L-23699B lubricants in the J79 engine were evaluated through discussions and inspection of engines

in the field. These evaluations were held at NARF's North Island and Quonset Point and Naval Air Stations Miramar and Oceana between August 1971 and January 1973. References c through e contain details of these evaluations including engine inspection reports. Discussions were held with: powerplant engineers, quality assurance personnel, examiners and evaluators, materials engineers, and chemists. The engines inspected had operating times ranging from 655 to 1597 total hours and up to 1386 hours since overhaul. The conditions of the lube system components of these engines are summarized in Table I.

7. These engines were inspected for condition of bearings, seals and gears as well as engine oil deposit levels. Bearings and gears were examined for corrosion and wear characteristics. Seals were examined for wear and proper seal action. Housings and sump areas were examined for deposits.

8. Deposit levels throughout the engines (i.e. deposits on sumps, bearings, breather and vent lines and seals) were evaluated as to type and extent of area covered. Deposits range from light sludges to varnishes to carbonaceous type deposits. Generally, only a build-up of loosely adhering carbonaceous deposits are of concern. The J79 engine was found to exhibit very good lubricant deposition characteristics (minimal deposition) as evidenced by the condition of engines in Table I.

9. Generally, bearings, gears and seals were found to be in good mechanical condition. However, some minor bearing and seal wear was noted as indicated in Table I and described in detail in references c and e. A summary of all reported lube system problems is given in Table II.

10. Operational problems and procedures, involving the lubricant and the lubrication system, at the squadron and the IMA levels were also investigated (references d and e).

11. Operational problems reported by the squadrons consisted of Constant Speed Drive (CSD) failures and high oil pressures on start-up. The CSD shaft failures were caused by heavy spline wear. Excessive wear of splines that are lubricated with a dry film lubricant, as these splines are, is not an uncommon occurrence. It has been noted through past experience that this wear is usually decreased when the splines are lubricated with engine oil. High oil pressure on start-up is an inherent J79 lube system/MIL-L-23699 oil characteristic when operating below +40°F. This condition has caused no known problems and therefore, remedial action is not considered necessary.

12. IMA personnel reported main scavenge filter element sludging and by-passing as indicated in Table II. Through follow-up investigation

it was found that this sludge is generated in the gearboxes. Through laboratory analysis it was determined that the main constituents of the sludge were magnesium salts. This sludge is generated when water gets into the gearbox, mixes with the oil, and attacks the magnesium surfaces. This sludge is then pumped through the main scavenge filter by the scavenge pumps of the gearboxes. The filter eventually becomes plugged and goes into a bypass condition. Occasionally, enough back pressure is built-up to fail the No. 3 scavenge pump. By following the path of the scavenge oil in Figure 1, a general J79 lube system schematic, it can be visualized how the above conditions could occur. This problem is under evaluation by the Navy and the engine manufacturer. The following changes have been implemented to date: (a) a repiping of the RA-5C aircraft application of the J79 engine to reduce its inherently high lube system back pressures and (b) an evaluation of disposable filter elements to preclude the possibility of improperly cleaned, partially plugged, elements going back into service.

13. In summary, the overall performance of MIL-L-23699B oils in the J79 engine, as indicated by engine condition, is considered to be satisfactory. Generally, deposit levels throughout these engines were light.

Performance - Oil Useful Life

14. The previous paragraphs discussed the deposition and lubrication characteristics of MIL-L-23699B oils in the J79 engine which were derived through inspections of disassembled engines. However, the remaining life margin of the lubricant cannot be predicted by this type of evaluation. Analyses of the ability of the lubricant to retain certain physical and chemical properties are necessary to accurately predict its remaining life margin. Therefore, in order to evaluate the retention of these properties, samples of lubricating oil from service engines were taken and subjected to laboratory testing. The following paragraphs are concerned with this part of the evaluation of MIL-L-23699B lubricating oil performance in the J79 engine.

15. A lube oil sampling program on the J79-GE-10 engine (in the F-4 aircraft) was initiated, with Fighter Squadron One Hundred-One (VF-101), in January 1972. This program started with five F-4 aircraft (ten engines) being placed on a sampling interval of fifty hours without oil drain. In all, 38 samples were received from VF-101 with time since last oil change ranging from 22 to 406 hours and total operating time ranging from 243 to 1081 hours. These samples were analyzed for changes in physical and chemical properties. The engines sampled were not all low time engines. The reason for this situation is that it was decided, at the initiation of the program, that engines with both high and low operating times would be sampled in order to determine lubricant property changes in the total operating range of service engines. As the program

progressed, sampling was discontinued on some units for various reasons (e.g. loss of oil, overhaul time reached, etc). The program was terminated in May, 1973.

16. Viscosities and Total Acid Numbers (TAN's) were used as the measure of the degree of change in the physical and chemical properties, respectively, of the oil. Viscosities and TAN's were used because they are the primary indicators of the degree of lubricant degradation.

17. Figure 2 is a graphical representation of viscosity and TAN values obtained versus oil time in five of the program engines. The five remaining engines experienced either oil losses or leaks which invalidated their usefulness to the program. As can be seen in Figure 2, there were no indications of oil degradation in any of the samples. Oil viscosity and TAN values did not vary significantly from new oil values indicating that no apparent physical or chemical changes in the lubricant occurred. The baseline tests, conducted on various batches of MIL-L-23699B (Qualification Number 0-9A) oil for comparison to program samples, gave values for viscosity (at 100°F) that ranged from 25 to 28 centistokes (cs) with an average value of 26.5 cs. The maximum value, for viscosity at 100°F, reached on a program sample was 28.1 cs. TAN's of the program samples, generally remained within new oil limits (i.e. less than 0.5).

18. Although the physical and chemical properties of the used oil from the program engines indicated that the oil had not degraded significantly, it was considered desirable to determine the margin of stability of the used oil. This would indicate the remaining useful life of the oil. Therefore, the oxidative stability and deposition characteristics of the used oil samples from the program engines, were evaluated by means of the 400°F Oxidation-Corrosion test and the High Temperature Deposition (HTD) test, respectively. These are laboratory and bench type tests that evaluate the lubricants resistance to oxidation and corrosive affect on various metals at elevated temperatures and the deposit forming tendencies of the lubricant at elevated temperatures.

19. The 400°F Oxidation-Corrosion testing was conducted on two program samples (one low time sample of 98 hours and one high time sample of 335 hours) from the same engine. These results were compared to new oil results. It was decided to run a low time and a high time sample in order to evaluate the oxidative stability near the extremes of operating times for the program samples. The results obtained were: (a) not significantly higher than new oil data and (b) within MIL-L-23699B specification limits for new oils. Therefore, it was concluded that: (a) the oxidative stability of the used oils remained essentially unchanged with aircraft oil operating times up to 335 hours, and (b) it was not necessary to conduct additional tests on samples with

intermediate operating times (i.e. more than 98 hours, but less than 335 hours). Table III shows the results of this testing.

20. A graphical representation of program sample viscosities and post Oxidation-Corrosion test viscosities is given in Figure 3. This figure shows that: (a) the viscosities of program samples up to 400 hours did not vary significantly from each other or from new oil values and (b) Oxidation-Corrosion test viscosities of program samples (at 98 and 335 hours) did not vary significantly from each other or from new oil Oxidation-Corrosion test results. Therefore, the oxidative stability and the corrosive tendencies of the program samples would be considered essentially those of new oil and the used oil was capable of at least another 335 hours of engine operation which would permit approximately 600 hours of engine operation without oil change.

21. HTD tests were conducted on 406 hour and 335 hour program samples. The results of these tests are compared to new oil results in Table IV. The test on the 406 hour sample was conducted first because this was the high time program sample. The results obtained on this test indicated that the deposition characteristics of the 406 hour sample significantly degraded from that of the new oil. It was therefore decided that another HTD test would be conducted on a program sample were with fewer operating hours. The results of the test conducted on the 335 hour sample indicated that its deposition characteristics did not vary significantly from the values obtained for the new oil. Therefore, this sample would be considered to possess the deposition characteristics of new oil, and was capable of at least another 335 hours of engine operation. In contrast, the 406-hour sample was not capable of another 406 hours of engine operation. It can be noted from the results (viscosity and TAN change) of Table IV that the stability of the oil in both tests, after the HTD test, had not been compromised. These data indicate that extending oil drain intervals to 600 hours would not increase engine deposits.

22. In summary, the overall performance of MIL-L-23699 oil in the J79 engine, as determined by evaluation of program samples, is considered to be satisfactory. The oxidative stability and the deposition characteristics of the used engine oil samples, up to 300+ hours, were essentially comparable to new oil values. Based on the extended additive activity shown by both the Oxidation-Corrosion and High Temperature Deposition tests, MIL-L-23699 oil is good for 600 hours of operation in the J79 engine without an oil change.

TABLE I
J79 ENGINE LUBE SYSTEM COMPONENTS

Total Hours	Hours Since Overhaul	Bearings		Seals	Housings	Gearbox	Model
		No. 1	No. 3				
655	New	-	W	GC	W	LV	-8C
690	244	-	-	-	-	GC	-10
691	New	W	GC	LV	-	GC	-10
982	New	SC	GC	W	-	-	-8C
982	New	GC	GC	LV	-	-	-10
993	New	GC	GC	LV	LV	-	-10
1069	926	GC	GC	LV	-	-	-8B
1117	New	W	W	LV	-	-	-10
1141	480	-	-	-	-	GC	-10
1262	450	GC	GC	LV	LV	-	-10
1308	837	GC	GC	LV	-	GC	-10
1383	New	-	-	-	-	GC	-10
1597	211	-	-	GC	W	LV	-8C

GC: Good Condition - good mechanical condition, negligible deposits.

LV: Light Varnish - lightest deposit level.

W: Wear - heavier than normal wear.

SC: Spotty Corrosion - small areas of spotting rust.

NOTE: The extent of disassembly of the above units varied with the reason for disassembly. Therefore, not all component of each engine were available for inspection.

TABLE II

J/9 ENGINE LUBE SYSTEM PROBLEM AREAS

<u>Problem</u>	<u>Cause</u>	<u>Reference</u>
Sludging and bypassing of main lube scavenge filter.	Sludge generated in gearbox.	c, d
No. 3 Scavenge Pump Failures.	Failures induced by back pressure and surging caused by plugged scavenge filter.	c, d
No. 2 and 3 Carbon Seals exhibit heavy wear.	Seal design deficiencies.	c
Bearing corrosion.	High moisture levels during periods of inactivity and in shipment to overhaul activity.	c, e
No. 2 Oil tube failures.	Fatigue failure of high time parts.	c
High oil pressure on start-up.	System characteristic with MIL-L-23699 oils.	e
CSD Spline Wear.	Inadequate lubrication with the dry lube used.	e
CSD Failures.	Shaft failures due to spline wear.	e

TABLE III
CORROSION-OXIDATION STABILITY TEST RESULTS FOR
NEW AND USED OILS FROM J79-GE-10 PROGRAM ENGINES
(72 HOURS AT 400°F)

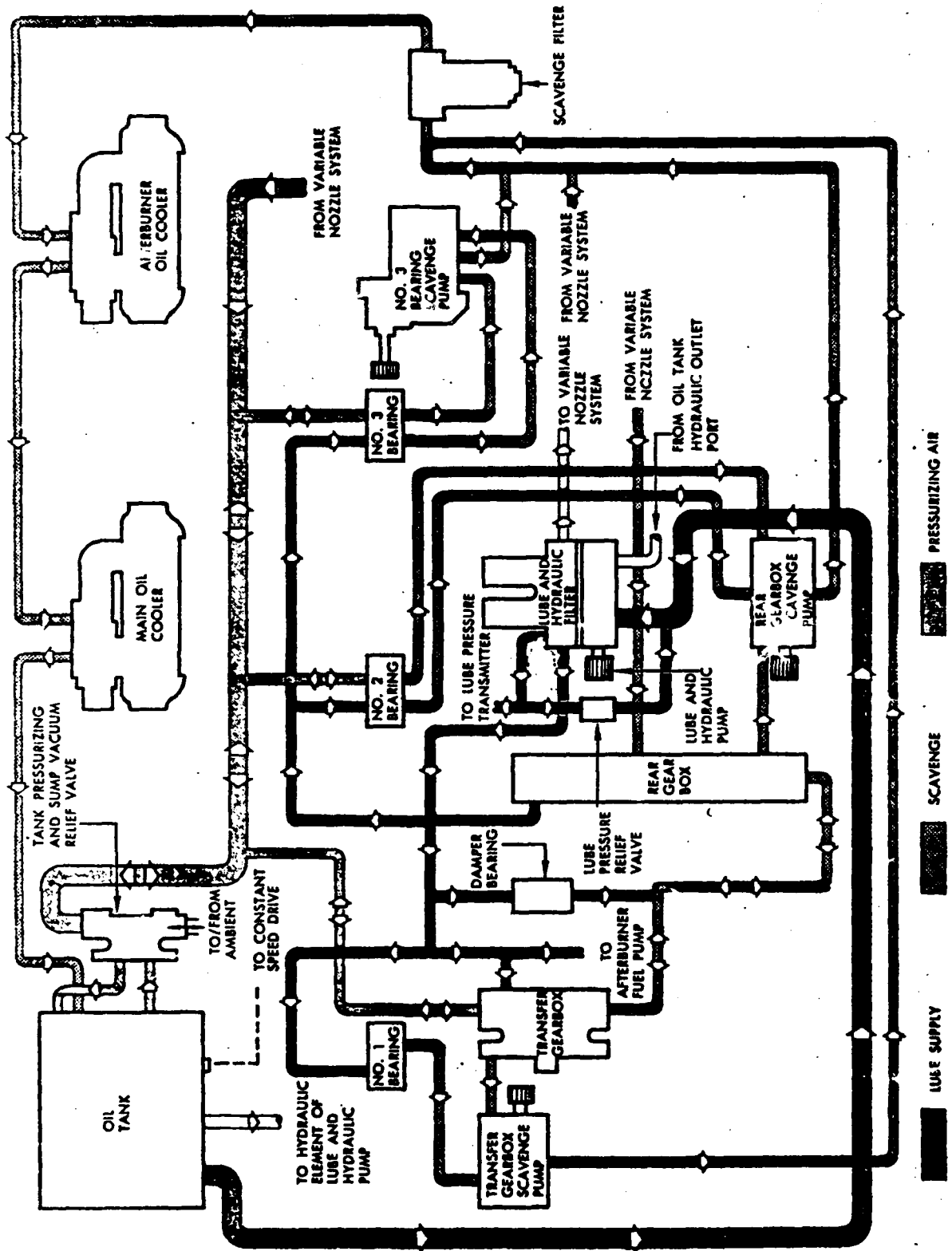
	MIL-L-23699 Specification Limit For New Oils	New 0-9A Oil	Used Oils	
			98 Hours	335 Hours
Initial Viscosity (100°F)	25 min.	28.0	27.0	26.89
Initial TAN	0.5 max.	0.22	0.13	0.20
Percent Viscosity Change (100°F)	-5 to +25	16.3	20.9	20.3
TAN Change	3.0 max.	1.21	1.02	1.08
Contamination mg./100 ml	50 max.	3.1	3.8	1.6
Metal Weight Change (mg)				
Steel	<u>+0.2</u>	0.00	+0.06	-0.01
Silver	<u>+0.2</u>	0.00	+0.04	-0.06
Aluminum	<u>+0.2</u>	0.00	+0.04	0.00
Magnesium	<u>+0.2</u>	0.00	+0.03	0.00
Copper	<u>+0.4</u>	0.00	-0.07	-0.13

TABLE IV
HIGH TEMPERATURE DEPOSITION TEST RESULTS FOR NEW
AND USED OILS FROM J79-GE-10 PROGRAM ENGINES
(525°F LOWER TUBE TEMPERATURE)

Non-Specification Test

	New 0-9A Oil	Used Program Samples		Range of MIL-L-23699 Results
		335 Hours	406 Hours	
Deposit Rating	9.0 - 18.0	10.8	50.6	0 - 34
Deposits (mg)	2 - 5	11	53	0 - 18
Filter Deposits (mg)	50 - 88	60	26	50 - 126
Oil Consumption (ml)	75 - 75	58	88	75 - 150
Percent Viscosity Change	11.5 - 10.9	14.7	18.7	10.9 - 23.9
TAN Change	1.0 - 0.95	0.19	0.66	0.68 - 1.41
Initial Viscosity (100°F)	28.00 - 28.00	26.88	27.32	25.81 - 28.14
Final Viscosity (100°F)	31.22 - 31.05	30.84	32.42	31.05 - 32.24

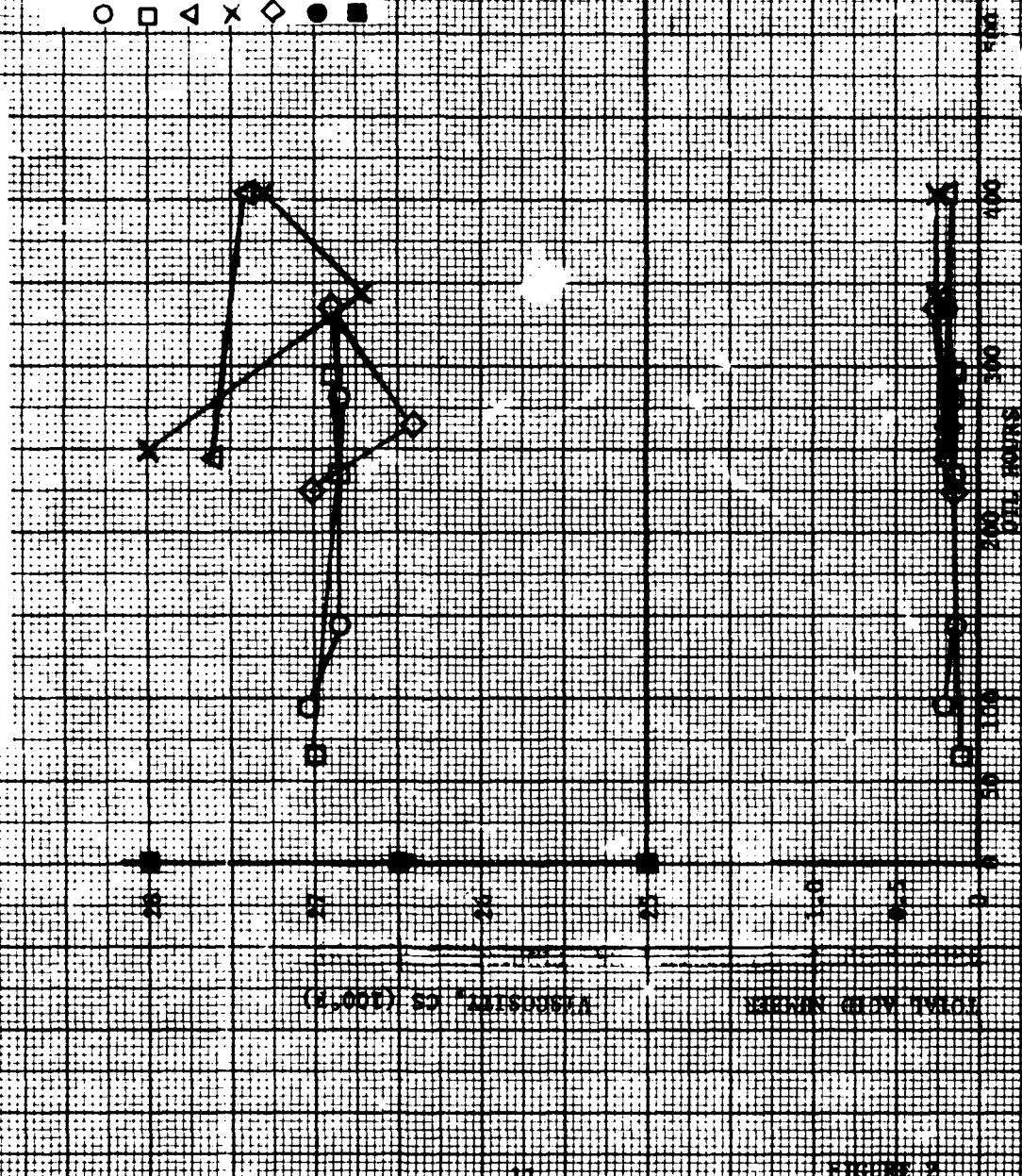
GENERAL J79 ENGINE LUBRICATION SYSTEM SCHEMATIC DIAGRAM



USED OIL VISCOSITIES AND TOTAL ACID NUMBERS

VERSUS

OIL HOURS FOR J79-GE-10 PROGRAM ENGINES



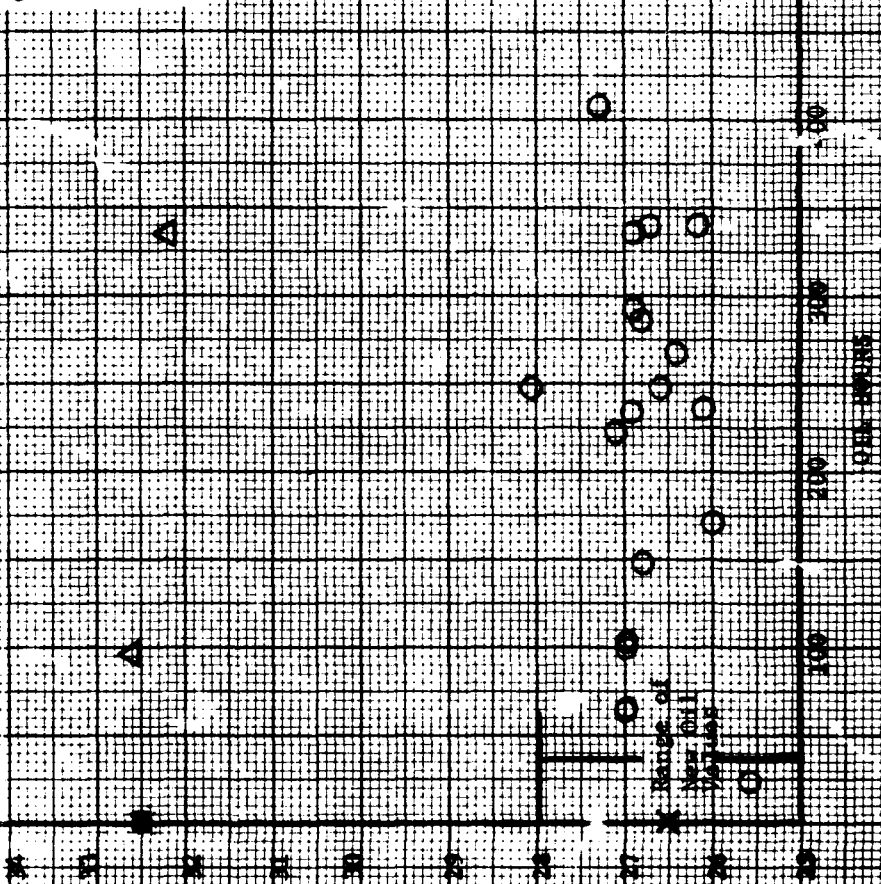
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FIGURE 2

VISCOSITIES AND 400°F OXIDATION CORROSION TEST DATA VERSUS OIL HOURS FOR 179-GE-10 PROGRAM ENGINE OIL SAMPLES

LEGEND

- O - Program Samples
- X - Average Value for New Oil
- - Oxidation-Corrosion Test on New Oil
- △ - Oxidation-Corrosion Test on Program Samples



(1.001) 80 VISCOSITY

N 77C-PE-39

REFERENCES

Reference material noted in this report is as follows:

- a. NAVAIR Work Unit Assignment No. NAPTC-316-4R6-113 - Analysis of Service Performance of Lubricating Oils.
- b. NAVAIR Work Unit Assignment No. NAPTC-316-4R6-113/3 - Analysis of the Service Performance of MIL-L-23699 Lubricating Oils in the J79 Turbojet Engine.
- c. NAPTC letter AEF2:FF:er 10350 Ser 328 of 28 March 1972 (NOTAL).
- d. NAPTC letter AEF2:FF:er 10350 Ser 337 of 30 March 1972 (NOTAL).
- e. NAPTC lettet PE72:FF:ss 10350 Ser F904 of 22 January 1973 (NOTAL).